Development and Function of Neural Circuits in Drosophila

Neural circuits underlie brain function and dysfunction. We are interested in how neural circuits develop; that is, what are the developmental programs used to assemble neural circuits. Discovering the “instructions” that program neural circuit formation will help design therapeutic treatments for replacing damaged or diseased neurons. We use the model system Drosophila (fruit fly) which has proven to be an accurate model for many aspects of mammalian development.

The first project will be to test the hypothesis that neuronal birth-order is important for generating neuronal circuits in the adult fly. The project involves genetics, cell biology, confocal imaging, and behavioral assays of adult flies in a “virtual reality arena.” The mentors will be a senior graduate student and a postdoctoral fellow.

The second project involves characterization of a neuronal population that, when activated, drives larval feeding behavior at the exclusion of all other behaviors (the larvae “eat” even when there is no food, and never do anything else). The work will involve genetics to visualize single neurons that control this behavior (“brainbow”), and using optogenetics to activate, silence, or monitor the activity of the neurons during feeding compared to other behaviors. The mentor will be a postdoctoral fellow.

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Neural circuits underlie brain function and dysfunction. To dissect and characterize circuits we need to first identify the neurons within a circuit, and then test models for how they initially form and are modified by experience. We are using the simple locomotor behavior of Drosophila larvae for this project. Drosophila larval locomotion is attractive because the behavior is simple and quantifiable; there are genetic tools to activate or silence individual neurons in the circuit; and our lab and others have characterized the development of these neurons in great detail. The project will involve expressing light- or temperature-controlled neuronal activity transgenes (channelrhodopsin or TRP1A to activate neurons; Kir or Shi to inactivate neurons) in different subsets of interneurons or motor neurons, and assaying the effect on larval locomotion. In collaboration with the Shawn Lockery's lab (University of Oregon), we have developed a method for live imaging freely behaving larvae while concurrently altering neuronal activity. We can also use Ca2+ indicators like GCAMP3 to watch the activity of single neurons in a freely behaving animal. A related project would involve Perl or Ruby programming to automate the analysis of these complex data sets. Overall, by linking molecular development of neurons to circuitry underlying behavior, these studies will give an integrated view of nervous system development.